account of their greater usefulness and superior adaptability, ultimately interfere with the development of the less useful ancestral stages and thus tend to replace them. The necessary corollary of this process would be tachygenesis or earlier appearrance of the ancestral stages in direct proportion to the number of new characteristics successively introduced into the direct line of modification during the evolution of a group.

If this be true, it can hardly be assumed that the loss of characteristics and parts taking place in this way is directly due to growth force. If growth has anything to do with these phenomena, it must act indirectly, and, as in the repetition of other similarities and parallelisms, under the controlling guiddance of heredity.

VARIATION AFTER BIRTH.

By L. H. Bailey.

At the present time, our attention is directed to differences or variations which are born with the individual. We are told that variation which is useful to the species is congenital, or born of the union—or the amalgamation in varying degrees—of parents which are unlike each other. From the variations which thus arise, natural selection chooses those which fit the conditions of life and destroys the remainder. That is, individuals are born unlike and unequal, and adaptation to environment is wholly the result of subsequent selection.

These are some of the practical conclusions of the NeoDarwinian philosophy. It seems to me that we are in danger of letting our speculations run away with us. Our philosophy should be tested now and then by direct observation and experiment, and thus be kept within the limits of probability. The writings of Darwin impress me in this quality more than in any other,—in the persistency and single-mindedness with which the author always goes to nature for his facts.

In this spirit, let us drop our speculations for a moment, and look at some of the commonest phenomena of plant life as they transpire all about us. We shall find that, for all we can see, most plants start equal, but eventually become unequal. It is undoubtedly true that every plant has individuality from the first, that is, that it differs in some minute degree from all other plants, the same as all animals possess differences of personality; but these inital individual differences are often entirely inadequate to account for the wide divergence which may occur between the members of any brood before they reach their maturity.

The greater number of plants, as I have said, start practically equal, but they soon become widely unlike. Now, everyone knows that these final unlikenesses are direct adaptations to the circumstances in which the plant lives. It is the effort to adapt itself to circumstances which gives rise to the variation. The whole structure of agriculture is built upon this fact. All the value of tillage, fertilizing and pruning lies in the modification which the plant is made to undergo. Observe, if you will, the wheat fields of any harvest time. Some fields are "uneven," as the farmers say; and you observe that this unevenness is plainly associated with the condition of the land. On dry knolls, the straw is short and the plant early; on moister and looser lands, the plant is tall, later, with long, well-filled heads; on very rich spots, the plants have had too much nitrogen and they grow too tall and "sappy," and the wheat "lodges" and does not fill. That is, the plants started equal, but they ended unequal. Another field of wheat may be very uniform throughout; it is said to be "a good stand," which only means, as you can observe for yourself, that the soil is uniform in quality and was equally well prepared in all parts. That is, the plants started equal, and they remained equal because the conditions were equal. Every crop that was ever grown in the soil enforces the same lessons. We know that variations in plants are very largely due to diverse conditions which arise after birth.

All these variations in land and other physical conditions are present in varying degrees in wild nature, and we know

that the same kind of adaptations to conditions are proceeding everywhere before our eyes. We cannot stroll afield without seeing it. Dandelions in the hollows, on the hillocks, in the roadside gravel, in the garden—they are all different dandelions, and we know that any one would have become the other if it had grown where the other does.

But aside from the differences arising directly from physical conditions of soil and temperature and moisture, and the like, there are differences in plants which are forced upon them by the struggle for life. We are apt to think that, as plants grow and crowd each other, the weaker ones die outright, because they were endowed with—that is, born with—different capabilities of withstanding the scuffle. As a matter of fact, however, the number of individuals in any area may remain the same or even increase, whilst, at the same time, every one of them is growing bigger. Early last summer I staked off an area of twenty inches square in a rich and weedy bit of land. When the first observations were made on the the 10th of July, the little plat had a population of 82 plants belonging to 10 species. Each plant was ambitious to fill the entire space, and yet it must compete with 81 other equally ambitious individuals. Yet, a month later, the number of plants had increased to 86, and late in September, when some of the plants had completed their growth and had died, there was still a population of 66. The censuses at the three dates were as follows :

	July 10.	Aug. 13.	Sept. 25.
Crab grass (Panicum sanguinale) .	22	20	15
Black Medick (Medicago lupulina) .	16	17	15
Purslane	14	15	12
White Clover	12	13	8
Red Clover	9	11	8
Red-root (Amarantus retroflexus) .	4	4	4
Ragweed (Ambrosia artemisæfolia) .	2	2	2
Pigeon-grass (Setaria glauca) . .	1	2	3
Pigweed (Chenopodium album) .	1	1	0
Shepherd's Purse	1	1	1
	82	86	66

What a happy family this was! In all this jostle up to the middle of August, during which every plant had increased its

bulk from two to twenty times, only the crab grass—apparently the most tenacious of them all—had fallen off; and yet the area seemed to be full in the beginning! How then, if all had grown bigger, could there have been an increase in numbers, or even a maintenance of the original population? In two ways: first, the plants were of widely different species of unlike habits, so that one plant could grow in a place where its neighbor could not. Whilst the pigweed was growing tall, the medick was creeping beneath it. This is the law of divergence of character, so well formulated by Darwin. It is a principle of wide application in agriculture. The farmer "seeds" his wheat-field to clover when it is so full of wheat that no more wheat can grow there, he grows pumpkins in a cornfield which is full of corn, and he grows docks and sticktights in the thickest orchards. Plants have no doubt adapted themselves directly, in the battle of life, to each other's company.

The second and chief reason for the maintenance of this dense population, was the fact that each plant grew to a different shape and stature, and each one acquired a different longevity; that is, they had varied, because they had to vary in order to live. So that, whilst all seemed to have an equal chance early in July, there were in August two great branching red-roots, one lusty ragweed and 83 other plants of various degrees of littleness. The third census, taken September 25th, is very interesting, because it shows that some of the plants of each of the dominant species had died or matured, whilst others were still growing. That is, the plants which were forced to remain small also matured early and thereby, by virtue of their smallness, they had lessened, by several days, the risk of living, and they had thus gained some advantage over their larger and stronger companions, which were still in danger of being killed by frost or accident. When winter finally set in, the little plat seemed to have been inhabited only by three big red-roots and two small ones and by one ragweed. The remains of these six plants stood stiff and assertive in the winds; but if one looked closer he saw the remains of many lesser plants, each "yielding seed after his kind," each one, no

doubt, having impressed something of its stature and form upon its seeds for resurrection of similar qualities in the following year. All this variation must have been the result of struggle for existence, for it is not conceivable that in less than two square feet of soil there could have been other conditions sufficiently diverse to have caused such marked unlikenesses; and I shall allow the plat to remain without defilement that I may observe the conflict in the years to come, and I shall also sow seeds from some of the unlike plants. From all these facts, I am bound to think that physical environment and struggle for life are both powerful causes of variation in plants which are born equal.

Still, the reader may say, like Weismann, that these differences were potentially present in the germ, that there was an inherited tendency for the given red-root to grow three feet tall when 85 other plants were grown alongside of it in twenty inches square of soil. Then let us try plants which had no germ plasm, that is, cuttings from maiden wood. A lot of cuttings were taken from one petunia plant, and these cuttings were grown singly in pots in perfectly uniform prepared soil, the pots being completely glazed with shellac and the bottoms closed to prevent drainage. Then each pot was given a weighed amount of different chemical fertilizer and supplied with perfectly like weighed quantities of water. All weak or unhealthy plants were thrown out, and a most painstaking effort was made to select perfectly equal plants. But very soon they were unequal. Those fed liberally on potash were short, those given nitrogen were tall and lusty; and the variations in floriferousness and maturity were remarkable. The data of maturity and productiveness were as follows:

Phosphate of Potash.	Sulphate of Potash.	Phosphate of Soda.	Check	Phosphate of Ammonia.
68 days	99 days	65 days	67 days	104 days
23½ blooms	18 blooms	27½ blooms	26½ blooms	33 blooms

Here then, is a variation of 39 days, or over a month in the time of first bloom, and of an average of 15 flowers per plant in asexual plants from the same stock, all of which started equal and which were grown in perfectly uniform conditions, save the one element of food.

But these or similar variations in cuttings are the commonest experiences of gardeners. Whilst some philosophers are contending that all variation comes through sexual union, the gardener has proof day by day that it is not so. In fact, he does not stop to consider the difference between seedlings and sexless plants in his efforts to improve a type, for he knows by experience that he is able to modify his plants in an equal degree, whatever the origin of the plants may have been. Very many of our best domestic plants are selections from plants which are always grown from cuttings or other asexual parts. A fruitgrower asked me to inspect a new blackberry which he had raised. "What is its parentage?" I asked. "Simply a selection from an extra good plant of Snyder" he answered; that is, selection by means of suckers, not by seedlings. The variety was clearly distinct from Snyder, whereupon I named it for him. The Snyder plants were originally all equal, all divisions in fact, of one plant, but because of change of soil or some other condition, some of the plants varied, and one of them, at least, is now the parent of a new variety.

But even Mr. Weismann would agree to all this, only he would add that these variations are of no use to the next generation, because he assumes that they cannot be perpetuated. Now, there are several ways of looking at this Weismannian philosophy. In the first place, so far as plants are concerned in it, it is mere assumption, and, therefore, does not demand refutation. In the second place, there is abundant asexual variation in flowering plants, as we have seen; and most fungi, which have run into numberless forms, are sexless. In the third place, since all agree that plants are intimately adapted to the conditions in which they live, it is violence to suppose that the very adaptations which are directly produced by those conditions are without permanent effect. In the fourth place, we know as a matter of common knowledge and also of direct experiment, that acquired characters in plants often are perpetuated.

I cannot hope to prove to the Weismannians that acquired characters may be hereditary, for their definition of an acquired

character has a habit of retreating into the germ where neither they nor anyone else can find it. But this proposition is easy enough of proof, viz., plants which start to all appearances perfectly equal, may be greatly modified by the conditions in which they grow; the seedlings of these plants may show these new features in few or many generations. Most of the new varieties of garden plants, of which about a thousand are introduced in North America each year, come about in just this way. A simple experiment made in our greenhouses also shows the truth of my proposition. Peas were grown under known conditions from seeds in the same manner as the petunias were, which I have mentioned. The plants varied widely. Seeds of these plants were saved and all sown in one soil, and the characters, somewhat diminished, appeared in the offspring. Seeds were again taken, and in the third generation the acquired characters were still discernible. The full details of this and similar experiments are waiting for separate publication. The whole philosophy of "selecting the best" for seed, by means of which all domestic plants have been so greatly ameliorated, rests upon the hereditability of these characters which arise after birth; and if the gardener did not possess this power of causing like plants to vary and then of perpetuating more or less completely the characters which he secures, he would at once quit the business because there would no longer be any reward for his efforts. Of course, the NeoDarwinians can say, upon the one hand, that all the variations which the gardener secures and keeps were potentially present in the germ, but they cannot prove it, neither can they make any gardener believe it; or, on the other hand, they can say that the new characters have somehow impressed themselves upon the germ, a proposition to which the gardener will not object because he does not care about the form of words so long as he is not disputed in the facts. Weismann admits that "climatic and other external influences" are capable of affecting the germ, or of producing "permanent variations," after they have operated "uniformly for a long period," or for more than one generation. Every annual plant dies at the end of the season, therefore whatever effect the environment may

have had upon it is lost, unless the effect is preserved in the seed; and it does not matter how many generations have lived under the given uniform environment, for the plant starts all over again, *de novo*, each year. Therefore, the environment must affect the annual plant in some one generation or not at all. It seems to me to be mere sophistry to say that in plants which start anew from seeds each year, the effect of environment is not felt until after a lapse of several generations, for if that were so the plant would simply take up life at the same place every year. This philosophy is equivalent to saying that characters which are acquired in any one generation are not hereditary until they have been transmitted at least once!

My contention then, is this: plants may start equal, either from seeds or asexual parts, but may end unequal; these inequalities or unlikenesses are largely the direct result of the conditions in which the plants grow; these unlikenesses may be transmitted either by seeds or buds. Or, to take a shorter phrase, congenital variations in plants may have received their initial impulse either in the preceding generation or in the sexual compact from which the plants sprung.

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A COMPARATIVE STUDY OF THE POINT OF ACUTE VISION IN THE VERTEBRATES.[1]

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In this preliminary sketch of a comparative study of the eyes of vertebrates, with special reference to the *fovea centralis* or point of acute vision, I shall first give the processes and methods of preparation which I have used and results obtained, and, second, the position of the *area centralis* as indicated by the retinal arteries. The microscopic descriptions and the relation of the position and shape of the eye and arrangement of the retinal elements to the habits of the animal will follow in a later paper.

[1] I wish to thank Dr. C. F. Hodge for valuable assistance and for his method of injecting the eye-ball, thus preserving it for complete sections. I am also very much indebted to Clark University for valuable aid and for apparatus and materials to further this study.